96/RE/64/Memari

Final Report

Report on Biomass Assessment Study in Memari block of the Burdhaman district (W. Bengal)

Financially supported by
Ministry of Non-Conventional Energy Sources
Govt. of India, New Delhi.

Commissioned by
West Bengal Renewable Energy Development Agency (WBREDA)
Salt Lake City, Calcutta, W. Bengal.

Report Submitted to
West Bengal Renewable Energy Development Agency (WBREDA),
Calcutta

Study done and report submitted by
Tata Energy Research Institute
Habitat Place, Lodi Road
New Delhi - 110 003

Tel: 4622246/4601550
Fax: 4621770/4632609
E-mail: mailbox@teri.ernet.in

September, 1997

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A suggested format for citing this report is given below

Sharma A., Ghose A., Gangopadhyay A.K. and Bagchi K., 1997.
Biomass Assessment Study in Memari block of the Burdhaman District, W. Bengal.
New Delhi: Tata Energy Research Institute, 34p.

To ascertain the avialbility of this report and theterms of supply, please write to

Renewable Resource Management Division
Tata Energy Research Institute
Habitat Place, Lodi Road
New Delhi - 110 003

Telphone: 4622246 / 460155
Fax: 4621770 / 463260
E-mail: ajays@teri.ernet.i

Research Team

Principal Investigator	Mr Ajay Sharma
Field Team	Mr Anit Ghose
	Ms Koushiki Bagchi
	Mr Diptendu Ghosh
	Ms Souragyoti Das
	Mr Raja Mukherjee
	Mr Ayan Kumar Gangopadhyay
Project Advisors	Dr V V N Kishore
	Mr P Venkata Ramana
	Mr Sameer Maithel
Administrative support	Mr G Gopalakrishnan

Acknowledgments

Our sincere gratitude to Dr. S. P. Gon Choudhari, Director, WBREDA for giving us the opportunity to undertake this study. We greatly appreciate the inputs provided Sh. T. K. Hazra, Addl. Director, WBREDA. We also appreciate Mr. Debasis Bose, District Planning Officer, Memari, Mr. Sukumar Das, BDO, Memari, Ms. Meghna Bhatacharya, BDO, Memari-II, Mr. A. P. Nandy, I.D.O., Mr. Sudhir Roy, MWI, Mr. Ranjit Banerjee, Mr. Gobinda Sarkar, Panchyat Secretary, Memari, Mr. Rafikuddin Ahmed, Panchyat Secretary, Memari-II for the their guidance.

Besides the officers, we got appreciable support from District Statistics Officer, Divisional Forest Officer and DIC office, Sadarghat, Burdhaman.

In course of study we interacted with researchers and Professors of Jhadav Pur University, Burdhaman University, Gram Pradhans, agriculture Extension Officers and households in the villages surveyed, and would like to thank them for their kind cooperation and hospitality.

Our thanks to Dr. R. K. Pachauri, Director, TERI, for his encouragement and support. Special thanks to colleagues in TERI for their helpful comments and patience.

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CHAPTER 1

Introduction

Majority of India's population lives in rural areas and depends primarily on biomass resources for meeting their energy demands. The use and management of rural energy needs focused planning, specially because of limited number of options available in rural areas. Very often energy planning in rural areas is considered synonymous with biomass planning and may be add the different kinds of biomass resources used thus such cases get linked to overall developmental planning. Biomass is generally being consumed by traditional devices, with low efficiency. Promotion of fuel-saving technologies such as Improved *chulha*, biogas plants, water heating devices have demonstrated the conservation and efficient use of different bio-fuels. Now the efforts are afoot to utilise biomass resources, in a more efficient manner, for power generation like sugarcane bagasse based co-generation in sugar industry and gasification of rice-husk. Such options are relatively new to India but these have now established their utility under laboratory-conditions as well as in field, in other countries too. However, the technologies are suitable for pilot demonstration level installations in India.

The consumption of dung and agricultural residues as fuel is widespread in agriculturally prosperous regions of the country. But fuelwood continues to be the main domestic fuel in less endowed and economically poorer regions. Fuelwood, agricultural residues and animal dung contribute between 90 and 95 per cent of the total fuel consumed in domestic sector and fuelwood alone accounts for 65 per cent (Natrajan and Sunder, 1985). Wood is also extensively consumed in rural industries e.g. brick and lime kilns, roadside restaurants, bakeries, etc. Generally crop-residues have low fuel value owing to herbaceous nature and are fed to livestock. But the residues from cotton, sugarcane, rice, etc. are being consumed for energy purposes. However, their mode of consumption is inefficient, linked with drudgery and finds limited applications.

India generates over 370 million tonnes of biomass every year. In addition to crop-residues, biomass is also produced as a by-product in many industrial processes. The prominent biomass by-products are rice-husk, saw-dust, sugarcane bagasse, coir-pith and groundnut shells. It is estimated that there are more than 60000 rice-mills in country and total production of rice-husk approximately 20 million tonnes annually. It has also been estimated that in addition to its present usage in domestic sector as fuel, India has a potential of generating

17000 MW of power by processing biomass through cogeneration, combustion and gasification routes

Biomass can effectively be used for power generation and moreover, of different capacities. Biomass resources are highly scattered and thus may be used for several options of energy uses. The options are direct combustion, gasification, pyrolysis, liquidification, etc. The gasification process involves the conversion of biomass to a high energy combustible gas for thermal applications and/or for use in an internal combustion engine to generate electric power. A biomass gasifier consists of a reactor where, under controlled temperature and air-supply, solid biomass is burnt to obtain a combustible gas. The gas passes through cooling and cleaning system before being fed into a compression-ignition engine to run in dual fuel mode. The engine is further connected to a alternator to produce electricity. Gasifiers up to 500 kW have been developed and demonstrated. Two co-generation units have been installed in Tamilnadu with a capacity of 3 x 2.5 MW for efficient use of bagasse. A rice-husk based 10.5 MW co-generation plant was also installed in 1990 in Punjab at an integrated rice processing unit which uses 5.5 MW and sells the surplus to State Electricity Board *(Source: Bhatnagar, 1997)*.

To tap the potential of various renewable resources of energy, a variety of technology dissemination programs are being implemented by the government in active collaboration with Non-governmental, international and grassroots organisations. But the expected objectives were not achieved primarily because of lapses in the proper conception of field realities while planning at a macro level and implementing it with target firing approach. In last two decades, complexities in rural energy planning have been seriously considered and linked with overall development planning by way of decentralised planning. To make decentralised planning more flexible, relevant and integrated with planning at higher levels, programmes are being implemented at block level such as the Integrated Rural Energy Programme (IREP) which was coordinated by Energy Cell of the Planning Commission. The Ministry of Non-conventional Energy Sources (MNES) earlier started with village level planning and implementation of projects under the *Urjagram* and Reference *Urjagram* programme. Later it attempted to develop methodology for district level energy planning in selected districts of the country. In order to be more effective in implementation as well as administration of energy activities, MNES has now chosen to devise energy plans at the block level. The studies are been undertaken in selected 100 blocks in different states.

One such scheme of developing block level planning aimed at 10 MW power generation by using biomass. Since the blocks have different area coverage by grid; levels of electrification; status of power supply and the power consumption pattern, these may have particular development priorities for power generation as well as for their consumption. The planning process has to deal with the supply of required fuel for power generation and the technology. The nature of supply, in terms of location and quantum, defines the size of power generation and hence the scope of proposed application. A large power generation unit may feed the local grid whereas a decentralised unit may energise some small community level applications. Moreover, isolated power generation may create a replicable demonstration of independent decentralised energy unit in the blocks which are not connected to grid.

Biomass or energy planning at any level would need a suitable database and the need is more urgent desperate at the micro-level. Most of the surveys gather very good information on biomass consumption side. However, due to various technical issues related to the availability of suitable data and to the technical nature of the resources, the biomass supply is not assessed in detail. Supply side computations are generally based on broad-based assumptions on land-use and regional level biomass productivities, wet to dry ratios, collection efficiencies, harvesting as well as collection practices, etc. However, for a micro-level planning the factors should be well researched at local level and included in the computations.

Status of power supply in West Bengal

West Bengal has an installed capacity of 3550 MW power and distributes 14296 Giga watts electricity, irrespective of the consumer. As per the provisional figures for 1995-96, the state has installed capacity of 5481 MW and generates 19215 MU[1]. The state has a deficit of almost six per cent (832 million kWh). Seventy six per cent of its villages are electrified but only 32.9 per cent households were electrified till the year 1992-93. The deficit compelled most of the major industries to install power production (730.2 MW) units to meet their demands. Iron & Steel (208.9 MW), textile (54.2 MW), fertilizer (55.1 MW) and mineral oil (31.5 MW) industries are the major private power producers. Small hydro power stations also generate 7.46 MW power and scattered solar photovoltaic (SPV) installations produce 83.43 kWh. The domestic sector also draws major fuel supply from cow-dung, coal and wood, subject to the availability in different districts. The power deficit, traditional dependance on local bio-fuels, and now number of households electrified (almost one-fourth villages are unelectrified) stress the need for substantial power generation and provide scope for decentralised independent power units. Since the districts under study rank among the major producers of paddy in state as well as country, the rice-husk may be a probable source of power generation here.

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[1] Economic Review - 1996/97, Govt. of W. Bengal.

Table 1.1 Distribution of households of the state by type of fuels in 1991 (%)

	Cattle dung	*Electricity*	*Coal*	*Charcoal*	*LPG*	*Wood*	*Biogas*	*Kerosene*	*Others*
State	18.04	0.21	23.57	2.12	4.87	32.13	0.22	3.69	15.03
Rural	24.48	0.09	10.94	1.96	0.57	41.54	0.18	0.32	19.87
Urban	2.18	0.52	54.65	2.52	15.44	9.00	0.33	11.99	3.12

Objective

The objective of the study is:

1. To make an assessment of biomass availability for 10MW power generation in Memari block of Dist. Burdhaman.

Scope of the report

The block level energy planning aims at assessing the biomass availability for large power generation. The study area is a pre-dominantly agricultural area and has a large area under rice cultivation. Three crops of rice are taken every year and practically a major portion of the land remains under rice in every cropping season. Moreover, rice is the major biomass resource as well as the only crop residue, in the area, for which proven technology for power generation exists. Though the study was designed to focus only on rice-husk and sugarcane residue production in Memari and Sainthia block, respectively, but residues from all other crops were also studied. However, estimation was made only for those suitable for proposed power generation. Cow-dung production and sustainable yields from forests and social forestry plantations were also estimated, which may not produce sufficient amount for large power generation but definitely have a role in meeting local energy requirements.

The pre-defined scope of the study restricts the study to assessment of biomass production potential for power generation and at the most its consumption. But Tata Energy Research Institute (TERI) proposed and in addition the study team explored the nature, location and size of the probable consumers in the area. In addition, priorities of the consumers in meeting power demands and then scanned were explored for and the suitable application for the proposed power generation.

The nature of study is primarily secondary data based and all relevant technical, financial and infrastructure related data were obtained from various Govt. Departments and Officers. However, a detailed questionnaire-based primary survey was also conducted to assess local development priorities and feasibility of power generation. A cross section of society was interviewed and different industries were surveyed as per the Ministry of Non-conventional Energy Sources (MNES) guidelines. The ground truth from primary survey also cross checked with the data from secondary sources. Hence major informations were obtained and not scientifically developed.

The chapter on the study area details demographic, geographic and meteorological information about the area. Most of information was collected from block office and some were procured at district headquarters. This section also highlights the contrast between two selected blocks on the basis of the available data on selected parameters. The methodology section deals with the data sources, general approach to the estimations and formulae used for computations. However, specific methodology for some of the computations have been given in the relevant sections.

The chapter on biomass assessment depicts the maximum potential availability of different biomass in the selected blocks. The availability has to be discounted for various enduses and local unrecorded consumption. Power generation potential by utilising the biomass resources for which small yields were available and/or associated practical difficulties in power generation, were also discussed along with the assessment. The resources are not discussed in the section on scenarios of power generation.

Actual rice-husk availability from individual rice-mills and from all the rice-mils collectively, was also calculated because the mills usually have a catchment area extending beyond the block boundaries. The information is provided in a special section on power generation potential using rice-husk. Besides this, the section also deals with the potential of power generation using different types of biomass resources, possible applications and the associated pre-requisites. The conclusions are drawn keeping in view the continuity of the biomass supply, local priority assigned to the application and its demonstration value.

CHAPTER 2

Study Area

The biomass availability for power generation was assessed in Memari block of district Burdhaman in West Bengal. The district is primarily agriculture based and agriculture is the major revenue generating activity. Out of the total population 70.9 per cent lives in rural areas.

Table 2.1. General information on Study area

S.No.	*Information*	*District Burdhaman*
1.	District H.Q.	Burdhaman
2.	Latitude	$22^{0}56'$ & $23^{0}53'$ N
3.	Longitude	$86^{0}48'$ & $88^{0}25'$ E
4.	Selected block	Memari
5.	Block H.Q.	Memari & Amedpur
6.	Development blocks	Memari-I and Memari-II
7.	Total blocks	32
8.	Major towns	Memari
9.	Railway Stn.	Memari
10.	National Highway	NH-2 (G.T. Road)
13.	Human population (1991)	3186833
12.	Urban	1154991
	Rural	2031842

Landuse

The block/taluka are identified as the police station areas in the state. Memari has two development blocks i.e., Memari-I and Memari-II with separate block headquarters. Memari block has more number of registered industries, higher agriculture production as well as productivity. However, hardly four villages have forest area in the village, in the block.

Table 2.2. Landuse in the selected blocks

S No	Information	Memari block
1	Geographical area	42180.03
2.	Cultivated area (ha)	34338.14
3	Irrigated area (ha)	28145.91
4.	Non-irrigated area (ha)	6192.33
5.	Culturable wastelands (ha)	492.07
6.	Forest area (ha)	4.05
7.	Constructed area (ha)	7345.67
8.	Number of villages	222
9.	No. of un-inhabitated villages	0(3 included in town)
10.	No. of Un-electrified village	104

Demographic data

District Burdhaman had 29.39 per cent population living in 49 towns and the selected block had only one town (Memari).

Table 2.3. Demographic details of the selected blocks

S.No.	Information	Memari block
1.	Human Population	275177
2.	Decadal growth (%)	26.31
3.	S.C. population	74237 (26.98)
4.	S.T. population	40774 (14.82)
5.	Literates in area	103498 (42.43)
6.	Literates in towns	8645 (51.27)
7.	Agriculture cultivators	21489 (7.81)
8.	Agriculture labourers	47089 (17.11)
9.	Industrial labourers	1809 (0.66)
10	Main workers	89586 (32.56)
11.	Marginal workers	2173 (0.79)
12.	Non-workers	183418 (66.65)

Note: *Figure in parenthesis reveal the percentage to the total population*

Meteorological data

The area falls in tropical zone and experiences hot and humid climate. The area gets an annual rainfall ranging between 1300 to 1500 mm, on an average. Temperature dips to 5°C in winter and shoots to 44°C in summers.

Table 2.4. Meteorological data for the study area

S. No.		*Dist. Burdhaman*		
		1989	1990	1991
1.	Annual Rainfall (mm)	1202	1557	1443
2.	Max^m Temperature (°C)	44	41	44
3.	Min^m Temperature (°C)	3	8	5

Industry

Generally service and manufacturing industries have developed in the study area. Major industries are rice-mills, cold storage and metal industries. The industries and market areas have developed along the major roads. Locations of the major industries have been marked in the maps in appendices (Annexure-III).

Table 2.6. Other details about selected districts

S.No.	*Details*	*Burdhaman*
1.	No. of primary & middle schools	233
2.	No. of High & Secondary schools	32
3.	No. of Private doc., dispensary, etc	46
4.	No. of Hospitals	2
5.	No. of Primary health centers	3

Though, the selected blocks are adjoining and have lot of apparent similarities but the blocks have contrast in terms of landuse, sources of irrigation, population density, urbanisation rate, industrialisation rate, development of market infra-structure and overall development growth rate.

Employment pattern

Burdhaman has such six towns namely, Asansol (7.64 lakh), Durgapur (4.16 lakh), Bardhaman (2.45 lakh), Ondal (2.21 lakh), Raniganj (1.56 lakh) and Kulti Barakar (1.09 lakh). The selected blocks are predominantly agricultural blocks. Area under Rice is 82.7 percent in the Bardhaman. Other major crops are Potato and Rapeseed. In the study area

53.41 per cent population in Burdhaman district is involved in agriculture. Manufacturing industries in Bardhaman are the second largest employers.

Status of Irrigation

Government canals and river water are the major sources of irrigation in the selected blocks. However, a variety of irrigation sources are being utilised for the purpose.

Table 2.5. Sources of Irrigation and area coverage

	Burdhaman	
S.No.	*Source*	*Area (ha)*
1.	R	336.69
2.	GC	14917.89
3.	TK	1169.51
4.	Tubewell with electricity (TWE)	997.0
5.	TW	363.39
6.	TW, TK, R	405.09
7.	GC, TW, TK	2976.08
8.	TWE, TK, R	796.42
9.	GC, TWE, TW, TK	859.15
10.	TW, R	28.33
11.	GC, TW, TK, R	573.03
12.	GC, TW	663.02
13.	GC, TWE, TK	1014.13

CHAPTER3

Methodology

Being a study in leading rice producing districts of country, it was primarily designed to estimate rice husk production. But the biomass availability in the form of cow-dung, other crop-residues and fuelwood was also assessed for the proposed power generation in the study area. The study was based on secondary information and later the calculations based on them were made. However detailed primary survey was also conducted to verify the secondary information and to study the local priorities associated with the proposed power generation as well as it's consumption.

Biomass supply

Secondary data was sought from District headquarter, office of the Block Development Officer, Industries Officer, District Planning officer, District Statistics Officer, Divisional Forest Officer, District Supplies officers, Agriculture officer, Panchayat Officer, Panchayat Sabhapati and Secretary, DIC office, Municiplity office, District Small Scale & Cottage Industries and University of Burdhaman. Latest published data, district Gazetteers, agricultural statistics and census records were taken B.G. Press (Calcutta). Primary survey included detailed discussions with Govt. Officials, elected member to Panchayats, Village Pradhan and villagers in 25 villages in the selected blocks.

Table 3.1. Data sources used during the study

S.No	*Information*	*Source*
At District Headquarter (Secondary Sources)		
1.	District and block level landuse	District Panchayt Officer
2.	Census records	Distt. Statistics Officer
3.	Kerosene, LPG supply	Distt. Supplies officer
4.	Industrial profile	Distt. Industry Officer
5.	Govt. Documents	B.G Press, Calcutta
At Block level		
6.	Landuse, Census, industrial profile, trends in urbanisation and industrialisation, Organised and Un-organised industries, agriculture markets	Local Block Development Officer & Officer
7.	Growing stock, sustainable yield of forests	Divisional Forest Officer, Forest Sur reports

S.No	*Information*	*Source*
8.	Crop-wise landuse, grain productivity, grain to straw ratio, Irrigation systems.	Block Agriculture Officer
	At Educational institutes	
9.	Crop-wise grain productivities, Land productivities status, biomass related ratios	Calcutta and Burdhaman Universities
	At Panchayat Level (Primary Survey)	
10.	Growth rates in population, Urbanisation, industrialisation, change in landuse, agriculture crop production, development of service sector, etc.	Panchayat Sabhapati, Secretary
11.	Livestock, Grain productivity, Energy & biomass consumption, biomass related ratios, Electrification, Agriculture development, market prices, etc.	Villagers
12.	Power requirement & consumption pattern, biomass processed or consumed, production process, electricity bills, details of generators, diesel consumption, power cuts, operational periods, etc.	Industries (Saw-mills, rice mills)

Agriculture residues

Secondary information was collected from two Block Offices for Memari -I and Memari -II blocks and district headquarters Burdhaman (Burdhaman).

Formulae used

Agricultural crop residues

Seasonal Rice-husk production = (Area under rice in a growing season x Grain productivity x Grain to husk ratio)

Annual Rice-husk production = Sum of Rice-husk production under Aus, Amon & Boro crop in the block

Same formulae is applied to estimate other crop residues also but rice is the dominant crop so the formulae is given for rice-husk only.

Cattle Dung

People try to collect all the possible cattle dung from the field and the collection efficiency from field was assumed to be 90 per cent. However, the grazing days are hardly extend over a fortnight. All the cow-dung from cattle-sheds was collected and thus the collection efficiency was 100 per cent. Generally the livestock is from local breeds and yields five kilogram dung per day.

Formulae used

Annual Dung Production = [{Avg. dung productivity x Total no. of cattle x Stallfed days x collection efficiency} + {Avg. dung productivity x Total no. of cattle x grazing days x collection efficiency}] x Wet to dry weight ratio

Tree canopies

There is negligible area under forests in the selected blocks and all the area was located in hardly in 10 percent villages. Moreover, the villages had scattered tree cover. The source may yield only little biomass but it was estimated by using the following the formulae

Formulae used

Growing stock = Area under plantation (or canopy) x productivity (per hectare)

Annual Sustainable Yield = Growing stock x 0.05

Productivity estimates made by Forest Survey of India (FSI) for the area were used (FSI, 1995). However, the similar information was also available in the ecological studies conducted by Bardhaman university. A factor of 0.05 was used to compute sustainable yield. It was selected on the basis the assumption taken by FSI that the local forests grow at the rate of five per cent per year.

Village-level biomass, conventional fuel and electricity consumption were estimated on the basis of primary survey, conducted in the selected villages. Similar data for neighboring district was taken from TERI's Rural Energy Database (REDB) and depicted in the relevant section.

Assessment of power consumption

Power consumption in the domestic sector was taken from secondary sources. Status of electrification, number of villages and household electrified were taken from District Statistics Officer. The consumption levels were verified with TERI's nationwide Rural Energy Data Base (REDB) and the information was sought from the database. A primary survey was also conducted for field verification and assessing the latest situation on status of electricity. A similar primary survey was also conducted for industries to estimate their sanctioned load, period of running, problems in meeting power requirements. A sanctioned load, annual electricity bill, size of diesel generators maintained and expenditures on diesel consumption were taken as the indicators of power crisis.

Assessment of power generation

Biomass processing technologies are under development and the input-output ratios are being standardised, specially for large size gasifiers. The biomass consumption has direct bearing on power generated. The ratio may vary with design of gasifier and the type of biomass consumed. Generally for the gasifiers that consume palliated biomass the following relation holds:

For generating 1kWh energy, a wood requirement is 1.5 kg.

Recently, workers have reported a requirement of 1.2 to 1.3 kg per unit of power generation. The ratio may improve over years and the biomass requirement may further reduce because of the continuing research, in the field. With the potential power generation, by using various biomass resources, the probable application and the associated prerequisites were observed and highlighted in relevant sections.

Selection of villages

The study focuses on land-based biomass resources hence the sample village selection was also made on the basis various types of land categories, i.e., Forest land, irrigated agr. land, Unirrigated agric. land, Irrigated land as percentage of total land, and total village area. In both the selected blocks, the data on the selected parameters was entered for all the villages and arranged in ascending order. Then it was classified in low, medium and high ranges by dividing the range of values for each of the parameters in three equal classes. Later the parameter on Forest land was dropped as only 4 villages in Memari and 21 villages in Sainthia had forest i.e., less than 10 per cent villages had forest. In that case the parameter was hardly representative.

It It became very obvious that more than 90 per cent of the population (the villages) fall in one category i.e., the population is highly uniform. It was also observed that all the parameters followed the similar trend (figure-1&2). The fact was further clarified by the graphs, where the peaks followed the similar trends. Further it could be concluded that any one of the parameter alone could capture the variation among the population. Reviewing the situation, the irrigated agriculture land as a percentage to the total land was selected for revealing the variation and sample selection. Since the rice-husk, expected to be the major

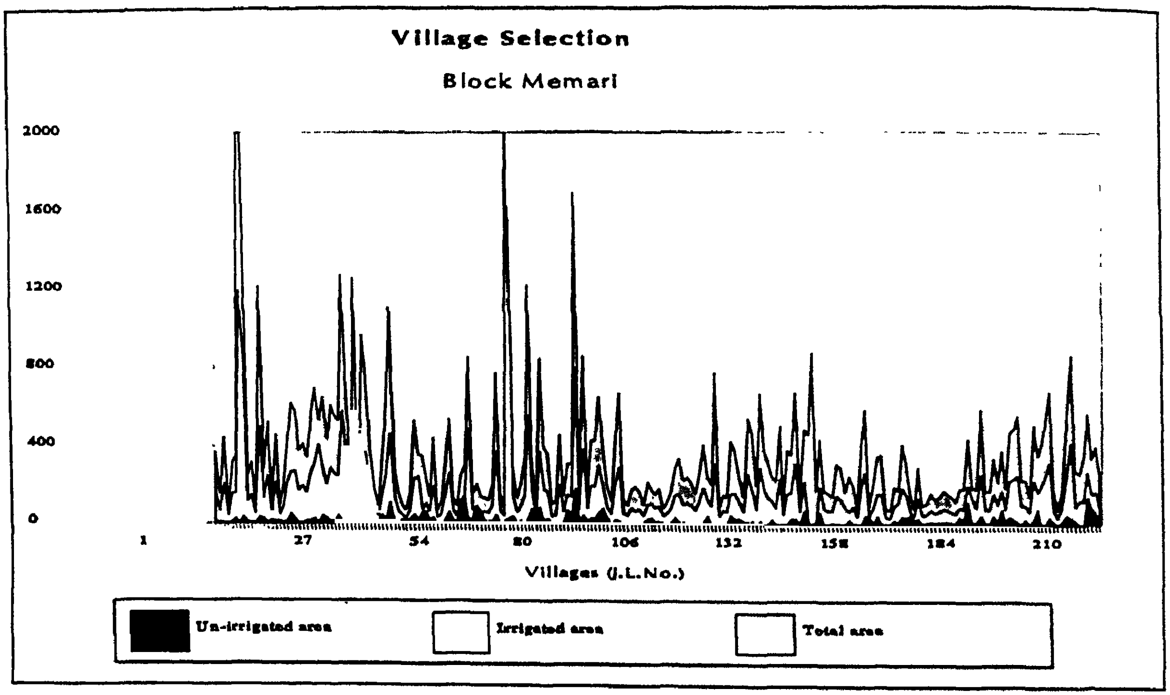

Figure 1 Village Selection in Memari block

biomass resource, was linked to the status of irrigation, the parameter was considered more relevant.

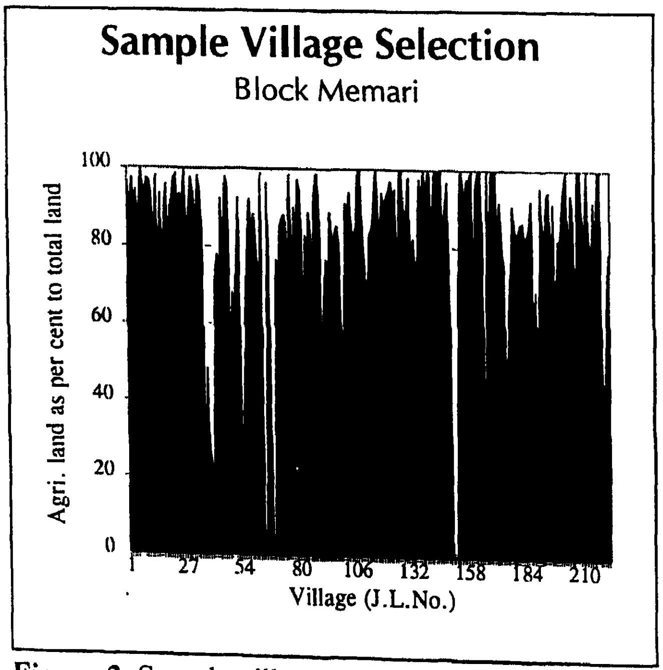

Figure 2. Sample village selection

Table 3.2. Summary of the data collected on various parameters in selected villages

Parameters	*Low*	*Medium*	*High*
In Memari block (District Burdhaman)			
Total land (ha)	0 - 450	450 - 900	900 - 1350
No. of villages	207 (93.6)	12 (5.4)	2 (1)
Irrigated land (ha)	0 - 700	700 - 1400	1400-2100
No. of villages	218 (98.5)	1 (0.5)	2 (1)
Un-irrigated land (ha)	0 - 170	170 - 340	340 - 510
No. of villages	217 (98.2)	3 (1.3)	1 (0.5)

Note - Figure in parenthesis denotes the percentage of total villages.

Table 3.3. The irrigated land as a percentage to total land (per cent)

	Memari block		
Class	*Villages (No.)*	*Sample size (No.)*	*Selected villages (J.L.No.)*
0 - 10	8	1	69
10 - 20	2	1	54
20 - 30	4	1	176
30 - 40	1	1	55
40 - 50	5	1	219
50 - 60	9	1	188
60 - 70	13	1	44
70 - 80	34	3	196, 172, 214
80 - 90	49	5	184, 59, 180, 28, 103
90 - 100	96	10	157, 24, 53, 81, 162, 11, 136, 89, 27, 212

All the villages in both the blocks were categorised in the ten classes of a class interval of ten per cent. proportionate sampling was done based on the number of villages in each class. A minimum of one village was selected from a class. Within a class villages were selected randomly. Finally 25 villages each were selected and studied in each block.

CHAPTER 4

Biomass assessment in Memari block

Biomass resources considered in the study include dung-cake, agricultural residues and wood that are used for energy purposes. The area being primarily rural, derives most of energy from land based and animal-based biomass resources. Most of the land in the area is used for irrigated agriculture and the homesteads also house dense vegetation. The area also gets long monsoons and therefore the lands are highly fertile and productive. In the given socioeconomic conditions the local biomass sources have an important role and offer considerable potential for energy end-uses. Thus all the sources were enumerated and assessed the potential in the selected blocks for power generation.

The present chapter has separate sections on biomass assessment in the block that detail information on various biomass resources. In the last, the biomass supply situations in the block has been consolidated to reveal the comprehensive situation, in brief.

Biomass availability in the block

The block is administered by two development blocks, i.e., Memari-I and Memari-II with their headquarters at Memari and Amedpur, respectively. The same set of information was gathered from the two places. The block has approximately 81 per cent of land under agriculture. Forests exit over 4 ha area only out of a total land of more than 42000 ha. The block is primarily rural and biomass based. Handmade coal briquettes is the main fuel in the domestic sector.

Cow dung

People generally maintain local breeds of cattle, goats and sheep. Only the economically stable families had cattle. On an average, livestock holding per family is three in the block but owing to the small sized local breeds the dung productivity is low.

Table 4.1. Livestock in the District Burdhaman

S.No	Livestock	Number
1.	Cow	1662274
2.	Buffalo	132242
3	Goat	124905
4.	Sheep	876496
5.	Donkey/ Horse	1313
6.	Pig	153911

Table 4.2. Information used for estimating cattle dung production in the area.

S.No.	Information	Value	Remarks
1.	Dung productivity	5 kg per day	Varies with seasons, higher in monsoons
2.	Collection efficiency	100 &90%	Total collection while stallfed and 90% when grazed.
3.	Grazing days	15 per year	During rainy seasons
4.	Dry to Wet ratio	0.25	Dry weight is 25% of the wet weight.
5.	Cattle population	117827	Computed based on the collected information.

Livestock computation

Total number of families	-	60424
Average livestock holding per family	-	3
Average proportion of families holding livestock(%)	-	65

Total livestock in the block = 28264 X 3 X 0.65 = 117827.

Cattle-dung production in Memari block (District Burdhaman)

Formula:

Annual Dung Production = [{Avg. dung productivity x Total no. of cattle x Stallfed days x collection efficiency} + {Avg. dung productivity x Total no. of cattle x grazing days x collection efficiency}] x Wet to dry weight ratio

Calculations:

[{117827X 5 X (90/100)X15}+{117827X 5 X (100/100) X 350}] X 0.25 = 53537 tonnes/yr.

Disposal of cow-dung

A quick decomposition rate of soil organic material in hot and a humid climate enriches soils of the study area and makes them fertile. So, the cow-dung that is usually used for manure and plastering purposes, is mainly used for fuel.

Table 4.3. Disposal of cow dung

S.No.	End use	Percentage diverted (%)
1.	Fuel	80
2.	Manure	15
3.	Plastering	5

Since most of the agricultural area is irrigated, people use chemical fertilizers. But for a minimum dose of organic matter @ 1 tonne Farm Yard Manure /ha/year, the block does not have sufficient cow-dung to manure 34338 hectare agriculture land. People are unable to divert cow-dung for manure purposes to increase the soil productivity. Therefore it may be concluded that there is no surplus dung for power generation. Nevertheless, the resource may be processed through biogas plants to obtain fuel gas and manure. Biogas may be consumed directly for cooking and/or power generation. Theoretically, the technology for power generation by biogas exists but for installing a pilot level demonstration, the infrastructure required to cater to scattered households and villages have to be considered. The infrastructure for collecting biomass, power generation, power distribution and distribution of dry biogas slurry is required.

Fuelwood

Fuelwood is harvested from various categories of land. Shrub wood, small poles, twigs, etc. are harvested from wastelands or common lands. Forests generally yield small timber and logs that are chopped to pieces and converted before consumption. The types of biomass harvested from a particular land use, depended on the vegetation cover. And, the land ownership defines the accessability to the resource.

Table 4.4. Fuelwood types and resources in the study area

Type of Fuelwood	Resources
Fuelwood from trees	Village forests, Govt. Managed forests & other lands
Logs or small poles from trees	Village forests, Govt. Managed forests & other lands
Shrub woods	Village common-lands, Village forests, Govt Managed forests & other lands.

The landuse records revealed that the block had only 4 ha or land that cannot generate sufficient biomass for the power generation, under natural and open systems of forest management. Therefore, no estimate was made for fuelwood from forests. The district has dense canopies in the areas close to Birbhum District (outside the block) which are highly pressed for local timber demand. However, the growing stock and the sustainable yield for the forests have been given in the **table 4.5.**

Table 4.5. Growing stock and sustainable yield in the Burdhaman district

Name	Forest area (Sq. km)	Area surveyed (Sq.km)	Stem/ha	Vol. / ha (m^3)	Total Volume (m^3)	Sus. Yield (@ 5 %) (m^3/ yr)	Sus. Yield (@ 5 %) (tonne / yr)
Burdhaman	159	159	468	10	287000	14350	21525

Disposal of fuelwood

Fuelwood collected from Government forests or social forestry plantations are sold by auction. The auctions are open to anybody from any part of the country. Local consumption of the auctioned wood is primarily for crematoriums and furniture industry. Mostly villagers gather fuelwood from their own lands or from forests, which goes unrecorded. However, the proportion of fuelwood is very small in the local fuel-mix.

Saw dust

The urban area of Memari has three saw mills which generally process Malaysian wood imported through independent traders.

Number of Saw mills in Memari - 3
Average saw dust production / day - 5 Qn.
The mills work for six months/ year - 120 days
Annual saw dust production = 3 X 5 X 120 = 1800 Qn. = 180 tonnes

Disposal of saw dust

People, in the urban settlements, burn Saw dust in traditional stoves for slow heating. The dust is sold at a price of Rs. 0.50/kg.

Agriculture crop residues

Traditionally the major agriculture crops in the area are rice, oil seeds, fibre crops and spices. A significant shift toward cash crops like vegetables, potato and pulses came in the last decade. Generally people feed animals with crop residues. Nevertheless, the residues from rice, mustard, a few pulses, sugarcane, etc. may be used for fuel purposes. The residues from vegetables, most of the pulses, spices and potato are herbaceous in nature and so far reliable technology for power generation from them is not available.

In the study area, the crop-wise land use data is compiled on an annual basis, unlike Northern states where it is aggregated separately for cropping seasons. However, season-wise area distribution is available for rice, under its vernacular names. In Memari block 86.81 per cent of agriculture area is under the rice.

Table 4.6. Rice cultivation calender

S.No.	*Name of Rice crop*	*Time period*	*Type*
1.	*Aus*	November - February	Good Quality rice
2.	*Amon*	June - September	Medium quality
3.	*Boro*	March - May	Coarse quality

The major agriculture crops in the area are rice, oil seeds, fibre crops and spices. While estimating the crop residue production it was observed that there was negligible area under sugarcane that may not yield sufficient crop residue for power generation. Crop residue from other crops were either food or fodder. Therefore the estimate of residue production was restricted to rice only.

Table 4.7. Crop-wise landuse in Memari block

S.No.	*Crop*	*Area (ha)*	S.No	*Crop*	*Area (ha)*
1.	Paddy	23500	5.	Vegetable	1130
2.	Oilseeds	2741	6.	Spices	1226
3.	Potato	6200	7	Pulses	21
4.	Wheat	175	8.	Sugarcane	0.5

Three estimates of productivity were available for different crops of the paddy, from different sources. However, the estimates given by local Agriculture Officers were used for computing the supply of agriculture residues.

Table 4.8. Area, grain productivity and production of Paddy in Memari block

S.No.	*Crop*	*Area (ha)*	*Grain Productivity (tonne/ha)*			*Grain Production (tonne)*
			Revenue Dept.	*Agriculture Dept*	*Primary Survey*	
1.	*Aus*	1545.22	2.735	2.671	2.060	4127.28
2.	*Amon*	19359.14	2.587	2.699	2.320	52250.32
3.	*Boro*	2595.64	2.710	3.076	2.614	7984.19

Grain to husk ratio for paddy	-	0.22
Annual paddy production in the area	-	64361.79 tonnes
Rice husk produced in the area	-	64361.79 X 0.22 = 14159.59 tonnes

Formulae used

Seasonal Rice-husk production =	(Area under rice in a growing season x Grain productivity x Grain to husk ratio)
Annual Rice-husk production =	Sum of Rice-husk production under Aus, Amon & Boro crop in the block

Major supply of paddy comes to market after rainy season and the supply was almost 85 per cent of the total paddy production in the area. In other two seasons, i.e., Aus and Boro, the remaining 5 and 10 per cent paddy is grown, respectively.

Overall supply situations in the block

A commercial level technology for using dung for power generation is not available and the wood yields are too small to use for power generation. However, both the resources in the block have been estimated and depicted in the **table 4.9.** Wood may come from various sources like village forests, social forestry plantations and Govt. Forests. The block has no Govt. Forests. However, the FSI estimates for the growing stock and sustainable yields are given for whole of the district (**Table 4.5**). In both the blocks, sufficient quantities of rice-husk were available for power generation.

Table 4.9. Assessment of different biomass for power generation in the block

S. No.	*Resource*	*Annual availability (tonne)*
Memari block		
1.	Cow dung	53557.00
2.	Wood	Nil
3.	Saw dust	180.00
4.	Rice husk	14159.59

The probable applications and the prerequisites associated to the resource-wise biomass availability in the block, were observed and are given in the relevant section in the chapter on the Scenarios of power generation.

CHAPTER 5

Scenarios of Power Generation

Introduction

Industrial, domestic and commercial sectors are major power consumers. With one-third households electrified, a domestic sector consumes electricity mostly for lighting. Due to limited supply of commercial fuels, domestic and a commercial sector derives a major share of energy from coke and cattle dung. A little quantity of fuelwood is consumed. The Industrial sector largely depends on electricity as the major industries are mineral, mining, metal, chemical and textile related. These three sectors are major power consumers in the study area and will be the probable consumers for the proposed power generation. However, industries besides consuming significant power, produce surplus biomass that may be used for power generation. Therefore the industries, which are probable producer and consumer of biomass-based power, have to be identified for the demonstration of the proposed power generation. Another option is to generate power for W. Bengal electricity Board. W. Bengal generates 19215.03 MU (Mega Unit) and runs in a deficit of 8458.94 MU of electricity.

The section detailed the power consumption in various sectors, scenarios of power generation and associated prerequisite. Power consumption was estimated based on the secondary information verified through a primary survey. For industrial sector, the consumption was assessed primarily for the industries that deal in biomass, some way or the other. However, major power consumers in the study area were also identified and their power consumption pattern is detailed. Separate sections deal with the power generation scenarios, possible applications and the associated prerequisites in the respective blocks. A summary table for each selected block is provided in Annexure - XIV and XV to reveal an overall scene.

Power consumption

Domestic and commercial sector

Both the sectors have intermingled in inhabitated area and there is no defined separate commercial sector. Also, the project aims at generating 10 MW power, commercial consumers with less than 5 kW power requirement were considered at par with domestic sector. So the sectors were clubbed. The domestic sector denotes an inhabitated area inclusive of commercial installations like markets, roadside hotels, tea-shops, etc. Moreover, the roadside hotels, tea-shops, etc. also primarily use softcoke or arrange kerosene oil. Therefore, their power consumption remains at par with that of a household unit.

Utilising biomass for an energy enduse is generally guided by its fuel value, availability and market price. In the study area major fuel used are dungcake, handmade coke and crop residues. The share of fuelwood is small and Kerosene oil is used only for lighting. LPG is not available in rural areas. The similar observations were made in earlier studies in the area compiled in TERI's Rural Energy Database (REDB).

Table 5.1. Domestic fuel consumption in the study area

S.No.	*Fuel consumed*	*Block Memari*
1.	Soft coke (kg / household / day)	3.55
2.	Wood (kg / household / day)	0.52
3.	Crop residues (kg / household / day)	0.43
4.	Dungcake (kg / household / day)	0.22
5.	Kerosene oil (lt / household / day)	0.09
6.	LPG .	Nil

The status of electrification as revealed by secondary sources is different from that observed in the field. It was observed that 75 per cent selected villages in the Memari block were electrified. However, the block had 48 per cent households electrified. According to the district level secondary information, more than 77 per cent villages are electrified but 33 per cent households in Memari were electrified. Because of the small number of households electrified, the average power consumption per household is small. The estimate of power consumption was based on the secondary information available on the aspect.

Power consumption in domestic sector of Memari Block

Power consumption per household - 0.08 kWh / household / day
Total number of household in Memari - 60424
Total Power consumption (Present) - 60424 X 0.08 X 365 = 1764380.8 KWH

Future Scenario

Percentage of households electrified - 33%

If all the households are electrified, the demand may rise at least 3 times.
In Memari - 1102738 X 3 = 3308214 KWH

The demand for power, in the study area is growing. With a rise in socio-economic status people will go for electricity connections and later for more & more electrical gadgets. When all the households will be electrified (i.e., number of households rising from one-third to the total), the total demand for power may rise at least three times.

Industrial sector

Biomass resources in the study area

The foremost objective of the study was to estimate power generation potential by using the biomass sources. So the study was focused on the industries that process biomass either as an input to production process or for energy purposes. Moreover, major industries in the study area are processing biomass. The industries require different quantities of biofuels and produce different types of biomass during their production process. People already have channels and procedures for disposing the biomass. Based on the disposal processes, a surplus biomass may be identified. The surplus biomass is the easiest to obtain for power generation. Other biomass resources may also be diverted for power generation but have some prerequisites.

Table 5.2. Disposal of various biomass outputs

S.No.	Biomass Output	Disposal	Price
1.	Rice-husk	Oil extraction (3%) In-house biofuel (15%) Local people consume as fuel (1%) Open burning without any enduse (81%)	Rs 3 per 40 kg Nil Nil Nil
2.	Sugarcane bagasse	The only sugar-mill (Ahmedpur) closed	
3.	Saw dust	Local people consume as fuel (100%)	Rs 0.50 per kg
4.	Bran oil cake	Artificial feed (100%)	Rs 10 per 40 kg

Different biomass generated in various industries are disposed off for particular enduses and have separate market price. The rice-husk has high silica content and is not fed to cattle and a large portion (more than 80 per cent) is burnt without any enduse. The residue may be easily diverted for power generation.

Biomass processing industries

Rice-mills, Bran oil-mill and Sugar-mill are the biomass processing units and the major electricity consumers in the area. Other major power consumers are Cold storage and the Cluster of industries. In very few cases, industrial houses have a mill-complex containing a rice-mill, a bran oil expeller and/or a cold storage in one compound. Moreover, the industries are maintaining huge generators to meet their power requirements. Sawmills are small unit consumers and needs 12-20 kW power. The industries that have a large power requirement and produce large quantities of surplus biomass may be the possible sites for power generation. However, the industries that have large power demand and are not producing any biomass (like Cold storage) have also expressed willingness to generate power.

The industrial profile of the study area reveals that most of the industries are related to food processing or post harvest technology, i.e., rice-mills, cold storage, oil-mills, sawmill, fibre processing and other cottage industries. The industries may be classified in three categories based on the method of Utilising biomass. There may be biofuel consuming industries, biomass handling but not producing biomass industries and biomass producing industries.

Table 5.3. Classification of the industries based on biomass use and probable application

	Biofuel consuming	*Handle Biomass in process*	*Produce biomass output*
Little heating requirement	Bakery, hotels, etc.		
Heating & Power requirement	Rice-mills, Sugar-mill,	Rice-mills, Bran oil mills, Sugar-mill,	Rice-mills, Bran oil mills, Sugar-mill
Little power requirement		*Furniture, truck body builders, Sawmill,*	*Sawmills*
Major power requirement		Cold Storage	Cluster of industries

Almost it is the same set of industries in all the categories. Nevertheless, the classification defines the process of biomass handling and thus the application of gasifier, e.g., in a Bakery only heating application is required and in a rice-mill a gasifier may be used for heating boilers and power generation. The industrial sector that provides an application for heating or have a small power requirement, may provide very low demonstration value for installing a gasifier for either of the purposes. So the priority may be given to power generation in biomass producing and/or large power consuming units.

Table 5.4. Profile of the major biomass producing industries

Industry	*No. of Units*	*Run for (months' / year)*
Small Rice mill	55	5
Big rice mill	18	12
Saw mill	3	4
Oil-mill	3	12
Cold storage	22	12
Cluster of industries	4	12

Table 5.5. Biomass produced and power consumption in biomass producing industries

Industry	*Biomass produced (tonne / year)*	*Power consumption (kWh / year)*	*Power cut (hrs/day in month/yr)*	*Standby Generator (KW)*
Small Rice mill	33	15000	4 hrs (4 M)	25-40
Big rice mill	1606	90000	7 hrs (6 M)	50-80
Saw mill	125	6000	5 hrs (4 M)	Nil
Oil-mill	300	24000	4 hrs (4M)	Nil
Cold storage	Nil	96000	6 hrs (6 M)	60-125
Cluster of industries	May not	108000	5 hrs (4 M)	80-175

Note : *The data have been computed for a unit on representative case basis*

Another interesting factor is Power cuts. Low voltage or single and double phase connections are also similar to power cuts, in bigger industries. Thus, duration of the cuts may vary with industries. Invariably all the industries identified summer months as problematic because power cuts for almost 5hrs every day. Most of the industrial units work for one-shift system and cannot afford to lose major work-time. So they maintain standby diesel run generators of large sizes. Besides the cost of running generator sets, the industries have to operate at less than their capacities, temporarily shut down some units, waste lots of labor, etc. while prioritising distribution and consumption of the standby power.

Power consumption scenarios

Meeting the power supply gap during the cuts, was identified as the major local priority. Along with it a few more consumption scenarios were considered for the proposed power generation. The scenarios were, a 20kW or 50kW generator running for 5 hrs daily which may energise small hamlet or street lighting in a village. A 50 KW generator running for 5 hr daily, in a small industry, would help meet the power demand during the cuts and the generator running for 10 hrs a day may replace dependance on the grid. Generators with a size varying between 100 kW - 500 kW running for 5 hrs daily may meet the power demand during power cuts. The same generator running for 10 hrs daily may generate sufficient power to reduce dependance on electricity grid. There is no single local consumer for 1 MW or bigger power generation. Such a large generation may be fed to the electricity grid, for monetary gains or an assured uninterrupted supply in summers. Most industries were interested to adopt power generation technology to cut down their expenditure on electricity and diesel bills. The priority showed that the locals are interested in adopting a cheaper powe generation technology.

Power generation scenarios

The power generation potential in Memari block centers around rice-husk, as the wood production is negligible in the area. However, the saw mills may sustain their power requirements by using sawdust for power generation through the gasification route. The sawdust production in three saw mills of Memari town, if fed to gasifiers, may run 20 kW generators for 5 hrs per day for whole of the year. Since the power requirement is just for four months, the size of generators may be doubled to meet all power demands.

Table 5.6. Potential power generation by using sawdust and applications in Memari block

			Number of days the power will last for, under following power consumption scenarios (Number of days)				
Biomass	*Quantity (tonnes)*	*Power generation (kWh)*	*20 kW generator for 5 /hr/day*	*50 kW generator for 5 /hr/day*	*50 kW generator for 10 /hr/day*	*1 MW generator for 5 /hr/day*	*Possible Applications*
Saw dust	180	120000	1200(1080) 3 units for 362 days	480(432) 2 units for 216 days	240(216) 1 units	24 (21)*	* Self sustainability * Sale to the grid

Note: * *Figures in parentheses are discounted number of days due to 10% processing losses*

The block has 55 small rice mills that operate for five months a year. These may be energized by installing 150 kW generators in every mill that will run for 10 hrs per day for five months. Larger installations of 500 kW generators operating for 5 hrs per day may meet requirements of 10 mills for almost 10 months. Major power requirements of all the four clusters of industries, in the area, may be met by running 500 kW gasifier-based generators for 10 hrs daily.

Table 5.7. Potential power generation by using rice husk and applications in Memari block

			Number of days the power will last for, under following power consumption scenarios (Number of days)				
Biomass	*Quantity (tonnes)*	*Power generation (kWh)*	*200 kW generator for 8 /hr/day*	*500 kW generator for 5 /hr/day*	*1 MW generator for 5/hr/day*	*1 MW generator for 16 /hr/day*	*Possible Applications*
Rice husk	14159.59	9439726.7	9440(7552) 25 units for 302 days	3776(3021) 10 units for 302 days	1888(1510) 5 units for 302 days	590 (472)* 2 units for 236 days	* Meeting power demand at cuts * Self sustainability * Sale to the grid

Note: * *Figures in parentheses are discounted number of days due to 20% processing losses*

Since there are no single consumers for power production bigger than 500 kWh, all the power generation may be sold to State Electricity Board (the local grid). A 2 MW power generation unit running for 16 hrs per day, may work for nearly 8 months per year, in the area. However, for such an installation major requirement is a procurement agency that would purchase surplus rice-husk from all the mills and from every village. Then transport the biomass to the power-generation plant. To transport whole of the rick-husk, trucks will have to make at least 1400 trips throughout the block. The economics involved in transportation should also be considered while taking the decision. Most of the industries have their standby generator sets and may allow any tempering with them only if the proposed technology is undoubtedly perfect. Moreover, if the enterprise is launched as a Government project, the market forces may behave differently. Generally the cost of operation by a Government organization is higher than that of a similar private organization or entrepreneur. However, problems may come to private organization also in procurement of raw material once the unit is installed due to professional reasons.

Prerequisite

Any entrepreneurer, venturing into power generation for more than 1 MW, would like to seek queries on the following:

1. Status of biomass supply
2. Status of technology, availability of repair and maintenance units
3. Economics of installation and operation
4. Status of electricity supply, chances of an up gradation of grid and nature of power cut
5. Infrastructural, logistic and legal support from Government agencies.

Status of biomass supply for various resources is being reviewed and discussed in the report and status of technology and availability of repair / maintenance units vary with manufactures and should be asked in detailed. A list of addresses of some manufacturers is given in Appendix VI. An economic feasibility for power generation by biomass and other conventional resources needs a separate detailed study. So, there are no comments on probable changes in economics of the power generation, its comparison with hydel power and grid expansion. However, relevant prerequisite have been highlighted while discussing the possible power generation and its applications.

Small decentralized power generation units may have to seek permission from Government authorities for power generation and public distribution. Normally, the state Electricity Boards discharge the duty and a new venture has to seek lots of clearances and permissions. Also they should develop a large infrastructure to obtain biomass and distribute power. An entrepreneur generating electricity for State Electricity Board would like to reach long term agreements with the Board WBREDA and State Forest Department (FD). To establish a fuelwood based power generating units, FD should assure sustainable fuelwood supply from forests or social forestry plantations.

If the power generation in individual mills aims at meeting the demands during power cuts or low voltage, the prerequisite to use gasifiers for the purpose is to have continuous (or long) power-cuts (say 4-5 hours/day). Gasifiers have to be charged, fired and heated to generate producer gas. The process takes 15-30 minutes. Therefore, gasifier may not be used in an off-on-mode or for short durations. So for the application, the State Electricity Board should ensure that power cuts are pre-announced and predetermined.

A detailed study of rice husk based power generation

Rice-husk is the major biomass resource in the block and may be used for large power generation. Therefore, further details on potential power generation from the resource are included in the following section.

Types of rice mills

Based on the quantum of the paddy processed, the rice mills are grossly classified into small and big rice mills. Besides the size, duration of operation (months/year), nature of the rice produced (polished/unpolished) and status of the mill (individual or cluster of industries), also define the size of a mill. Another difference is the scatter pattern and location of these mills. The small mills are in rural area and along the small district roads. The large industries are around towns and connected to National or State Highways. The location is characterized by the type of the farmer/customer utilising the service. Small farmers get their paddy de-husked at small rice mills (shellers) and people who produce good quality and big quantity go to large rice mills. Marginal farmers who have paddy for subsistence only shell it at their places. Interestingly that the major quantity of paddy comes to big mills and whatever is available with small mills or households also comes to market through an informal but moderately organized marketing system. Migrants from Bangladesh have settled in the parts of the study area, particularly along the National Highway No.2 (G T Road). Most of them earn their livelihood by trading in rice husk. They get the husk from villages and sell it to oil mills in town.

Table 5.8. Characteristics of the rice mills in the area

		Units		Grains handled	Operate for	Total husk production (tons/year)		Avg. Husk produced per mill
Size	Product	Memari I	Memari II	tons/day	(month)	Memari I	Memari II	
Small	Unpolished rice	25	30	1-2 (1)	5	825	990	33
Large	Polished	8	10	12-40 (20)	12	12848	16060	1606

Note: *1.* *Values in parentheses were chosen for calculations, for the given range*

2 *Husk to grain ratio is 0.22 per cent*

Small rice mills process 1000 to 2000 kg paddy and a large rice mill process 1200 to 4000 kg/day. Average of the ranges was not taken as the representative case because most of the respondents believed that small rice mills process 1000 kg/day and a large mill process almost 20,000 kg paddy/day.

Biomass availability

Rice husk availability in selected blocks revealed sufficient biomass availability for energising all the small rice mills. However, the rice husk availability may vary because all the husk may not come to markets or mills, a share also goes to oil extraction industry and above all, a significant share is consumed for heating boilers. To energise big rice mills, the required rice-husk has to be pooled. The biomass availability may change if number of mills contribute their resource and the benefit flows to a few mills or consumers. The industries would like to discuss the sharing pattern for biomass resource and the benefit, in detail. Still, the biomass supply scenario may change. Therefore, power generation potential of rice mills and biomass availability for the purpose should be assessed from the point of view of rice mills.

Table 5.9 Rice husk availability in the area (tonnes/year)

Block	Calculated as per secondary survey	Calculated as per primary survey	Available for powe generation (@ 75%
Memari	14159.59	30724	23043

The rice husk availability, as per the primary survey is much more than the total production in the area which may mean that the catchment area for the mills is much larger than the respective blocks. Doubting the results from primary surveys is difficult because all the large rice mills are given a license to shell 12 tons per day (300 bags of 40 kg each/day). However, every respondent felt that due to the general hike in prices of inputs and other practical reasons, it becomes economical to run a mill beyond 400 bags per day and generally the mills process 700-1000 bags per day. However, for calculations, the representative case was taken to be 500 bags per day. Moreover, it is suggested to use the lower limits of biomass supply potential, while preparing a long term biomass management plan or devising biomass based energy interventions. The supply could be higher because there are reasons to believe that respondents at mills were rating the production, lower than actual.

The rice mills not only had higher husk availability, thus the potential for power generation, but also have standby generators ranging between 80-175 kW capacity. Moreover, all the respondents at mills were keen to get the gasifier installed and ensured the rick husk supply even if it were to be bought.

Power generation

The technology available and the husk availability in the areas supports large power generation (say more than 200 kW). The power generation scenarios have been reviewed from the point of capital power generation (in MW) and building sustainability of rice-mills in meeting their power requirements (in kW).

Table 5.10. Power generation in rice mills (As per primary survey)

Block	*Husk production (tonne/year)*	*Power generation (kWh)*	*200 kW generator for 10 hr/day*	*500 kW generator for 10 hr/day*	*2 MW generator for 10 hr/day**	*Possible Application*
Overall scenario						
Memari	23043	15362000			768.10 days (614.48 days) 2 units for 307 days	* Sale to Electricity Board
Representative case						
Small mill	25*	16667	8 days	-	-	-
Large mill	1200*	800000	400 days (320days) 1 unit for 10 months	160 days (128days) 1 unit for 4 months	-	* Sustainability in meeting power demands

Note: 1. *Figures in parentheses are number of days discounted for 20% loss of husk due to transportation, storage and handling.*

2. *The supply (*) figures are 75% of the total supply (discounting supply for other enduses).*

Evidently, large rice mills may generate sufficient power to meet their electricity demands for almost ten months in a year, by processing their production of rice husk through gasification routes and that too after meeting their requirement for fuel purposes. However, the industry may have to depend on the grid for at least two months a year. On a collective basis, if the surplus rice husk is pooled and electricity is produced for State Electricity Board, the area has potential to generate 4 MW for 10 months in Memari block. The husk supply may run two units of 2 MW each running for 10 hours per day. Keeping in view the scatter pattern, location of rice mills and presence of grid, it may be suggested that the power generation units for Memari block may be installed at village Baghila (J L No.154) or Nudipur (J L

No.209) (both near Memari town) and second unit may be installed in village Parhati (J L No.122). The location of large rice mills and organised industrial sectors have been marked in maps (Appendix III).

It is learnt that rice husk based gasifier technology is available for 500 kW generators and for other sizes, both smaller and bigger, the technology has to be scanned. Though the calculations have been made for 200 kW but the installations will be pilot level projects, only.

Related economics

Presently all the industries are spending a huge amount on electricity supply but are not satisfied. They maintain diesel run generators and looking for cheaper options. The electricity bill varies between Rs 15,000-42,000 per month and annual expenditure on diesel is Rs 60,000-1,50,000 at the present cost of diesel. During power cuts, they run at lower capacity and lose significantly, in more than one way.

The mill authorities were found agreeable to invest up to Rs 3 lakhs for installation and would not even mind Rs 50,000 as annual recurring cost for running and maintenance.

Prerequisite

Most of the prerequisites have been enlisted earlier. Still, a few, as expressed by rice mill owners are detailed below. However, most of these are technology related.

1. People are not familiar with the gasifier technology and have apprehensions. So in-depth extension and introduction to technology are required. All possible support may be extended during the demonstration phase.
2. Since the technology is new, entrepreneurs are hesitant in spending huge money for installation or capital investment. Also they would like minimum tampering with their generators, if those are used.
3. The technology should be as trouble free as the generator sets and maintenance or repair units should be readily available. Perhaps locals are trained on gasifiers. An entrepreneur may not like to lose because of technological failures.
4. The formalities involved in seeking permission for power generation may be reduced and an agreement with the Electricity Board may be simplified.

CHAPTER 6

Conclusions

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1. In Memari block power may be generated by processing rice husk through a gasification route. Power may be generated by saw dust, and fuelwood derived from village forests and social forestry plantations. In the area, a huge amount of cattle dung is also available but may not be used for power generation.

2. There is potential for power generation at different levels and for various consumers. Power may be generated; at individual industry level for power sustainability or meeting the power demands at the time of power cuts; at community level to energise street lights in villages; or it may be a massive power generation for State Electricity Board. All the options have respective associated prerequisites.

3. Highest priority is attached to large power generation based on rice husk. Two units of 2 MW each may be installed in Memari. The units will run for ten months in Memari. The estimate is based on the rice husk availability with rice mills.

4. All the large rice mills produce sufficient rice husks to generate power to meet their demands for almost 10 months. Since the industries have large consumption of power and are financially sound to share initial installation cost, the application of the proposed power generation also holds good demonstration value and prospects.

5. Small rice mills and saw mills may attain sustainability in meeting their power requirement. However, the application is rated low as the sectors work for 4-6 months hence the demonstration remains idle for major part of the year. Moreover, the industries may not go for high investment cost and complex technologies.

6. Cold storage and cluster of industries are also large scale power consumers and provide scope for demonstration of a decentralised independent power generation unit. However, the economics of power generation should be attractive. They may ask for some incentives.

7. West Bengal Renewable Energy Development Agency may procure rice husk and start generating power for grid. The demonstration may encourage private

entrepreneurs to take up the idea as an industry for domestic sector electrification and creation of decentralised independent energy/power units.

8. At village level, street lights may be energised or all the households in small villages may be given one point per household connections if WBREDA takes up installation of small size gasifier and power generation units. The demonstration is costly but has great social value.

9. Availability of rice husk with rice mills is higher than the total rice husk production in area. It may be ascribed to much larger catchment area for the rice mills.

10. Most of the rice husk produced in the area enters into market system, either formal (mills) or informal (Bangladeshi migrants). However, major shares of rice-husk comes to rice mills and if more is required, it may be bought from the informal market.

11. High resource availability like cattle dung and herbaceous crop-residues; a coke-based energy consumption pattern; little electrification and low economic status, etc. provide opportunities for establishment of decentralised energy systems or reference *Urjagram*. Biogas, improved chulha, and solar power based equipment and technologies may find enormous adoption. The feasibility studies on the lines may be initiated.

Any of the option may be explored in detail and pilot level demonstration may be installed. Most of the options call for economic incentives, sharing of installation cost, smoothening of logistics and massive extension work.

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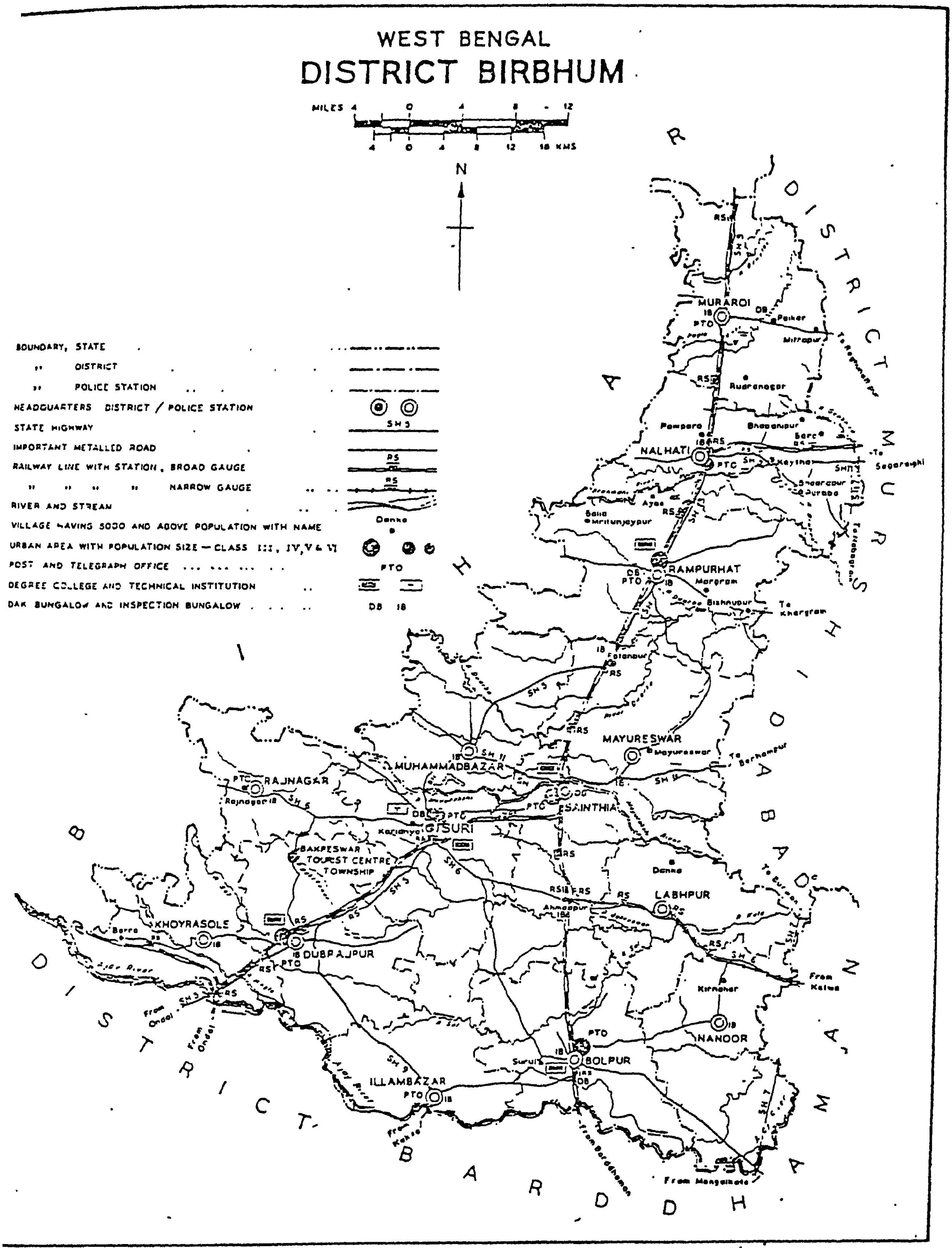
Annexure - I.

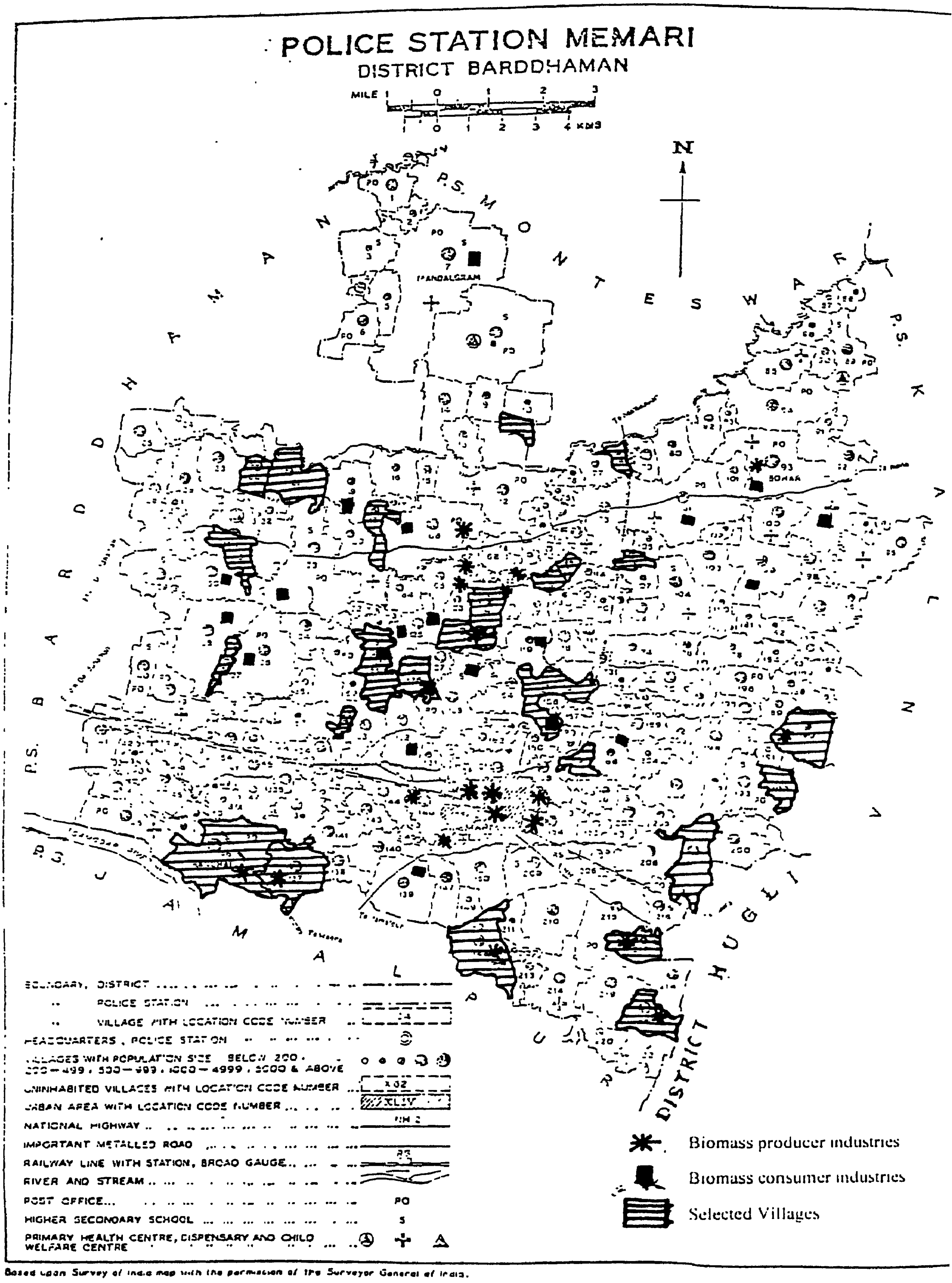
Map of district Birbhum



pon Survey of India map with the permission of the Surveyor General of India

Appendix - II

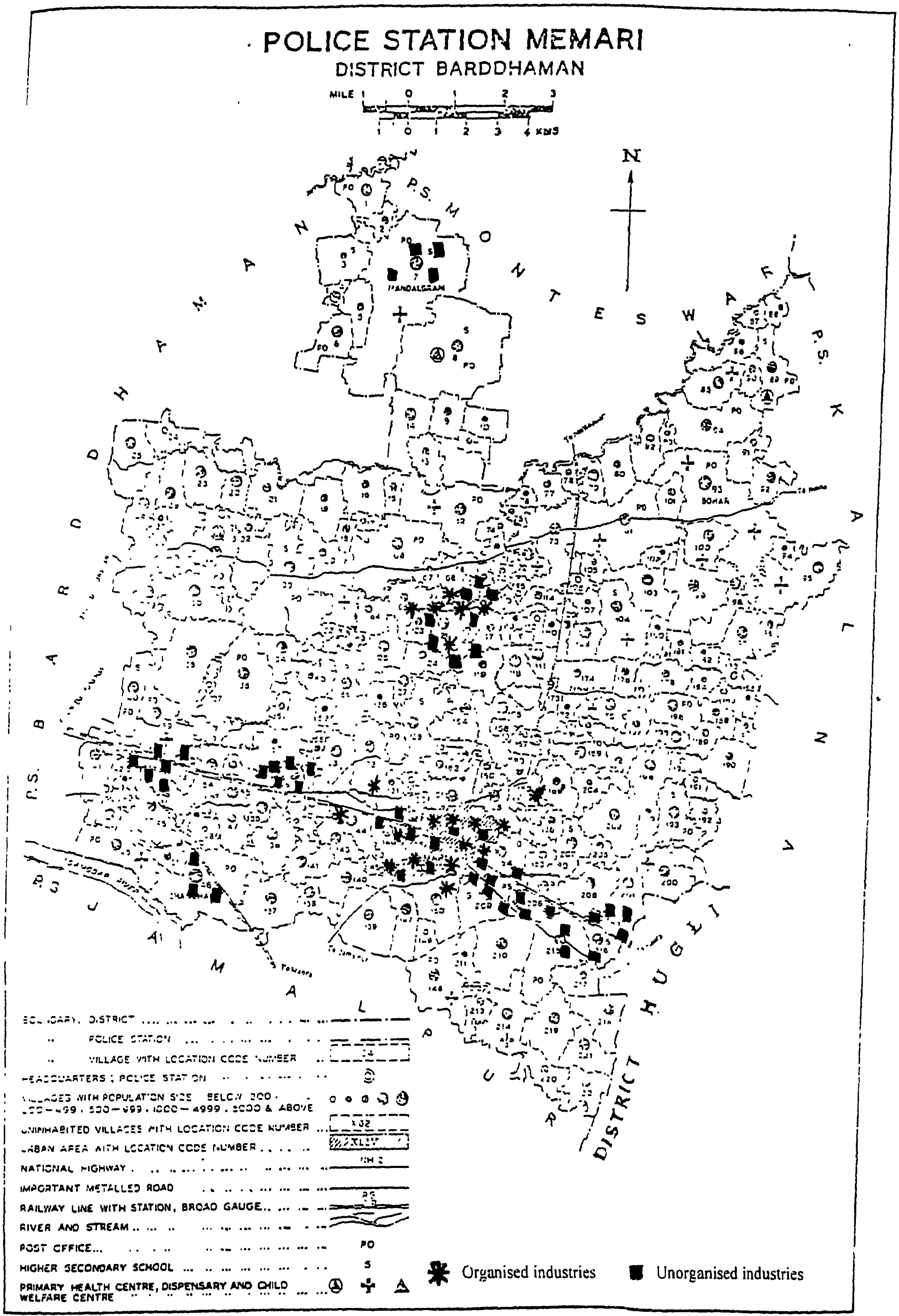
Map of Memari block with selected villages


POLICE STATION MEMARI
DISTRICT BARDDHAMAN
MILE 1 0 1 2 3
1 0 1 2 3 4 KMS
N
P.S. MONTESWAR
P.S. KALNA
HUGLI DISTRICT
P.S. BARDDHAMAN
P.S. JAMALPUR
MANDALGRAM
BOHAR
BOUNDARY, DISTRICT
" POLICE STATION
" VILLAGE WITH LOCATION CODE NUMBER
HEADQUARTERS, POLICE STATION
VILLAGES WITH POPULATION SIZE BELOW 200, 200—499, 500—999, 1000—4999, 5000 & ABOVE
UNINHABITED VILLAGES WITH LOCATION CODE NUMBER
URBAN AREA WITH LOCATION CODE NUMBER
XLIV
NATIONAL HIGHWAY
NH 2
IMPORTANT METALLED ROAD
RAILWAY LINE WITH STATION, BROAD GAUGE
RIVER AND STREAM
POST OFFICE
PO
HIGHER SECONDARY SCHOOL
S
PRIMARY HEALTH CENTRE, DISPENSARY AND CHILD WELFARE CENTRE
Biomass producer industries
Biomass consumer industries
Selected Villages

Based upon Survey of India map with the permission of the Surveyor General of India.

Appendix - III

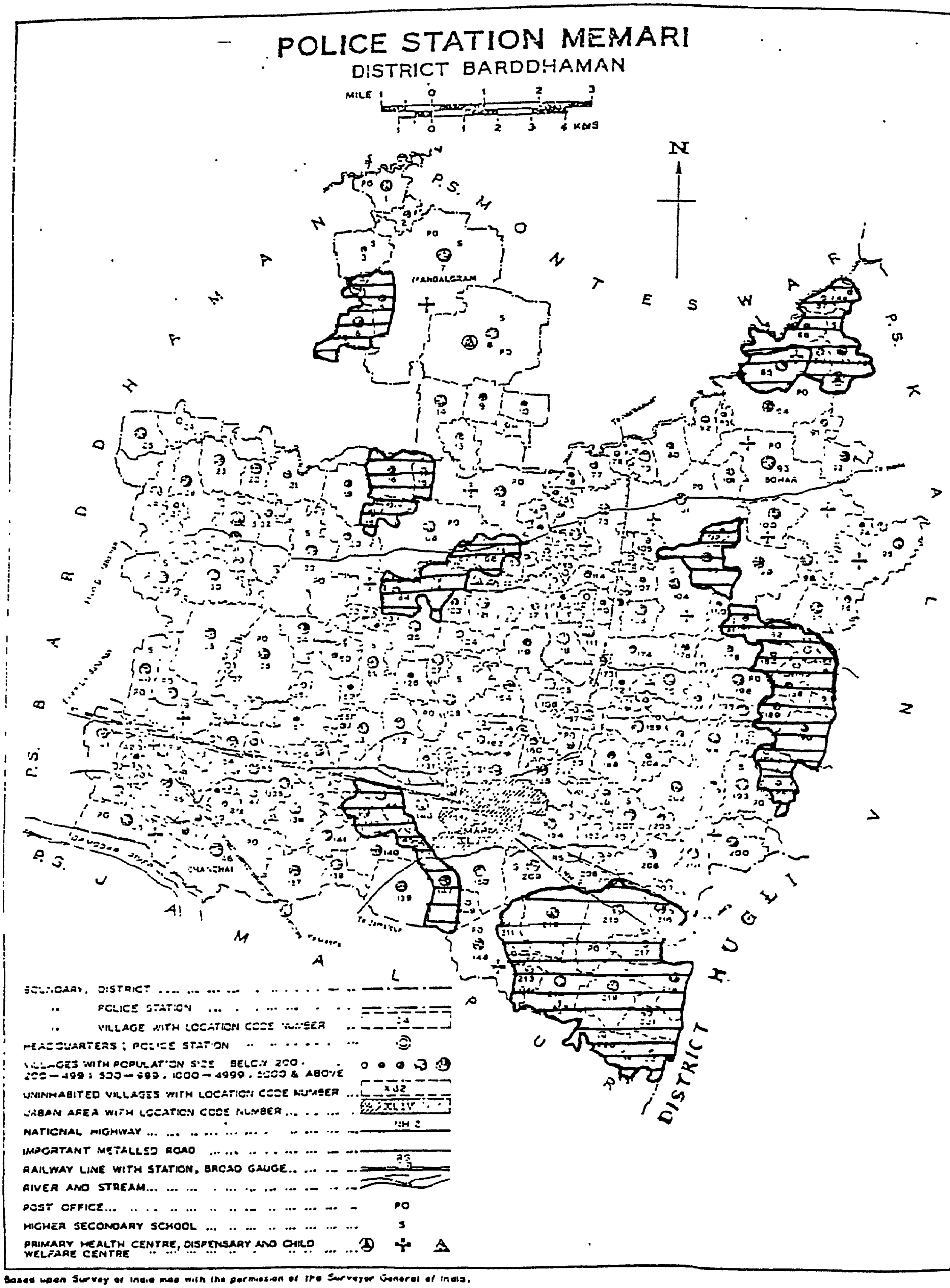
Map of Memari block with location of industries marked



Based upon Survey of India map with the permission of the Surveyor General of India.

Appendix - IV

Location of Un-electrified villages in Memari block


POLICE STATION MEMARI
DISTRICT BARDDHAMAN
MILE 1 0 1 2 3
1 0 1 2 3 4 KMS
N
P.S. MONTESWAR
P.S. KALNA
P.S. BARDDHAMAN
P.S. JAMALPUR
DISTRICT HUGLI
PANDALGRAM
BOHAR
MEMARI
SATGACHHI
BOUNDARY, DISTRICT
" POLICE STATION
" VILLAGE WITH LOCATION CODE NUMBER
HEADQUARTERS : POLICE STATION
VILLAGES WITH POPULATION SIZE BELOW 200 ; 200—499 ; 500—999 ; 1000—4999 ; 5000 & ABOVE
UNINHABITED VILLAGES WITH LOCATION CODE NUMBER
URBAN AREA WITH LOCATION CODE NUMBER
NATIONAL HIGHWAY
IMPORTANT METALLED ROAD
RAILWAY LINE WITH STATION, BROAD GAUGE
RIVER AND STREAM
POST OFFICE ... PO
HIGHER SECONDARY SCHOOL ... S
PRIMARY HEALTH CENTRE, DISPENSARY AND CHILD WELFARE CENTRE

Based upon Survey of India map with the permission of the Surveyor General of India.

Appendix - V

Brief note on Gasifire technology

Biomass gasifier system

The gasifier system to be coupled to the diesel genset consists of (i) fuel processing unit, (ii) main gasifier, (iii) gas cleaning/cooling train and (iv) waste utilization unit. These are described briefly below.

The fuel processing system is designed so as to process most biomass residues. The different routes for biomass processing are shown in Figure 1. It consists of a wood cutter, a chopper, a pulveriser and a ram and piston type briquetting (densifying) machine. The wood cutter is primarily used for cutting long pieces of wood into smaller (~ 5 cm x 10 cm) pieces, which are desirable as they ensure smooth fuel flow within the gasifier thus avoiding bridging. Agricultural residues like corn cobs, coconut shells, cashewnüt shells etc. can be used directly without any preprocessing. Residues like mustard stalks, cotton stalks, lantana etc. can be chopped and used directly, provided they have a reasonably good bulk densities (~ 250 kg/m^3). The chopper is a conventional chaf cutter extensively used in rural areas for fodder cutting. Biomass residues such as groundnut (peanut) shells will have to be pulverized and then densified. The pulveriser is a conventional hammer mill grinder available easily in the market. Items like saw dust can be directly briquetted. The briquetting machine is a commercially available ram and piston type, which has gained popularity and commercial acceptance in recent years. These units will use some of the power generated by the power plant, but as they are not used simultaneously, they do not draw heavy load. The electricity consumption for the various biomass processing units is in the range of 0.02-0.1 kWh/kg.

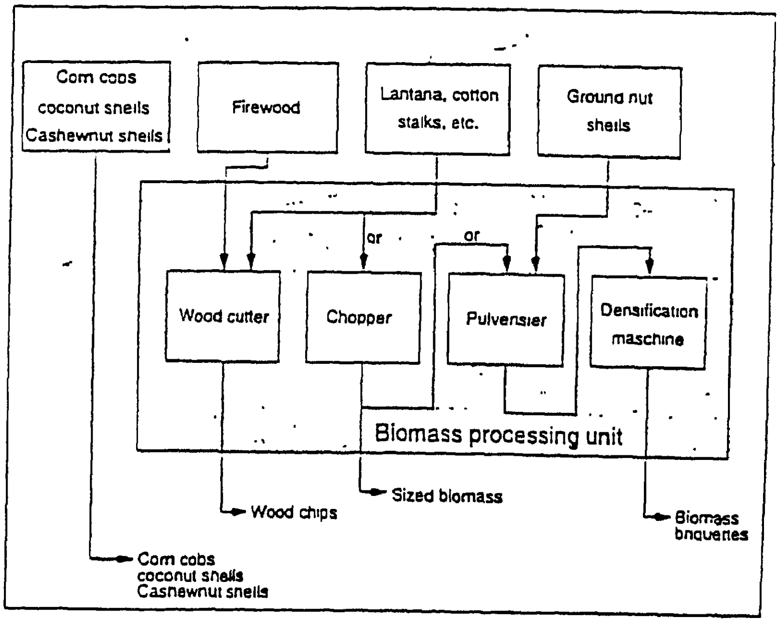


Figure 1. Routes for biomass processing

The main gasifier is a downdraft throatless design with a low specific gasification rate and provided with a continuous char removal system. It consists of a fuel hopper (storage bin), the reaction zone, a vibrating grate, all provided in a integral unit. In its travel through the gasifier, biomass drying and oxidation (combustion) undergoes followed by conversion to producer gas and char. The char is collected in a water pond below the grate and the gas is taken out through a bottom side port for further cleaning. Fuel is charged from the top through a gas-tight port, which is opened and closed manually. The storage bin accommodates sufficient fuel for a 2 hour operation at full load. However, as the gasifier is under slight vacuum, fuel can be changed at frequent intervals without interrupting gas production or power generation. Two air nozzles are provided for combustion. The technical details of the gasifier are listed below.

Type : Downdraft, throatless
Specific gasification ratio : 0.1 Nm^3/cm^2 hr
Gas production : 2.3-2.5 Nm^3/kg
Gas calorific value : 1000-1200 $kcal/Nm^3$
Cold gas efficiency (energy in gas/energy in biomass) : 70-80%

The raw gas contains appreciable amounts of tar and solid particulate matter, to the tune of 1500-2000 ppm. The impurity levels should be reduced to about 50 ppm before admitting the gas into any internal combustion engine. This is achieved by passing the gas through a series of units viz., a gravity settling chamber, a cyclone, a venturi scrubber, a packed bed scrubber, a sand bed filter and a paper filter, as shown in Figure 2. By the end of cooling/cleaning train, the producer gas is at ambient temperature and the total impurity content is down to 30-50 ppm. The water used for cleaning/cooling is recycled after screening for solid particles, and passing through a natural draft cooling tower.

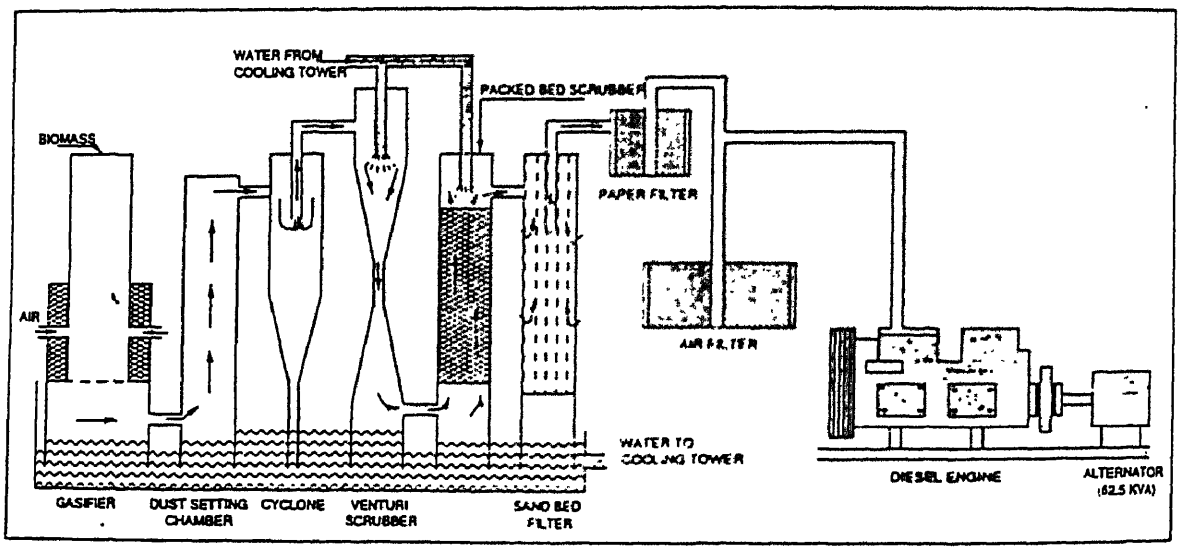


Figure 2. Schematic diagram of the gasifier based power generation set-up

The principle waste produced is biomass char and the tar and particulate matter collected while cleaning the gas. The gasifier is designed so as to produce char and not ash. The char and other solid matter collected in the water tanks is mixed and allowed to sun-dry for a day or two. After this it was fed to a low pressure screw extruder for making char briquettes. Analysis of these briquettes showed that they contain 50% carbon, 40% ash and minor quantities of hydrogen and nitrogen. The calorific value of the briquettes was in the range of 3500-4000 kcal/kg. The briquettes are thus suitable for sale as solid fuel to commercial enterprises like road side hotels.

The complete power plant

Gas produced from biomass as described above, is fed into a suitable diesel genset. The capacity and specifications of the genset are selected a-priori and the capacity of gasifier and other sub-systems are designed in accordance. For example, for a 62.5 kVA genset with 6 cylinders of swept volume 6.614 litre and 1500 RPM, the gasifier will have to be designed to consume about 50 kg biomass/hour. The producer gas, when burnt inside the diesel engine along with diesel oil, will replace upto 70% of diesel. The diesel replacement figures for a 50 kW gasifier power plant are shown in Figure.3 for different fuels. On a continuous basis, the power plant consumes about 108 ml diesel and 1.1 kg biomass to produce 1 kWh of electricity. Out of this, about 10% is used for parasitic consumption and the result is available either for feeding into the grid or for captive utilization.

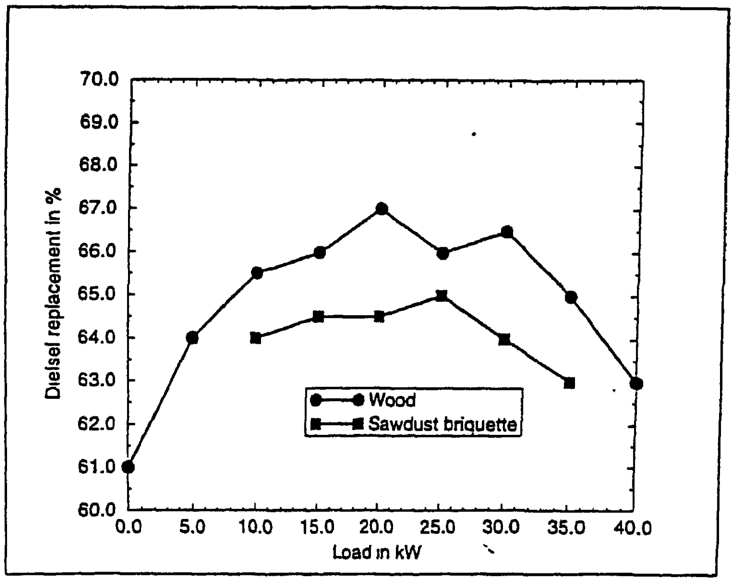


Figure 3. Diesel replacement achieved with dual fuel mode operation of diesel genset

Appendix - VI

List of groups developing Gasifires and Rice furnace

1. The Regional Centre for Extension Service
Modernisation of Rice Processing
Annamalai University, Annamalai Nagar
Tamil Nadu

2. The post Harvest Technology Scheme
College of Agricultural Engineering
Punjabrao Krishi Vidyapeeth
Akola, Maharashtra

3. Department of Processing and Agricultural Structures
College of Agricultural Engineering
Punjab Agriculture University
Ludhiana, Punjab

4. The Rice Processing Engineering Centre
Dept. of Agricultural Engineering
Indian Institute of Technology
Kharagpur, West Bengal

5. Department of Agricultural Engineering
College of Technology
G B Pant University of Agriculture & Technology
Pant Nagar, U. P.

6. Post Harvest Technology Scheme
Agricultural Engineering Institute
University of Agricultural Sciences
Raichur, Karnataka

7. M/s Krishi Sewa
Naroda Industrial Township
Naroda, Ahmedabad, Gujrat

8. M/s Wanson (India) Ltd.
Chinchwad
Pune, Maharashtra

9. M/s MG Industries
Batala, Punjab

10. IIT, Powai, Mumbai.

11. KSCST, IISc, Bangalore

12. IIT, Hauz khas, New Delhi.

13 School of Energy studies
Punjab Agriculture Unviersity
Ludhiana, Punjab.

14. Tata Energy Research institute
Habitat Place, Lodi Road
New Delhi - 110 003.

15. Thapar Corporate R&D Centre
Patiala, Punjab.

16. Ankur Scientific Energy Technologies Pvt. Ltd.
Near Old Sama Jakat Naka
Vadodra - 390 008, Gujrat.

17. M/s Associated Engineering Works
PB No. 17, Chivatam Road
Tanuku - 534 211

18. M/s Electrotech
E - 61, Industrial Phase - VIII
S.A.S. Nagar, Mohali, Punjab.

19. Janta Refractory & Steel Rolling Mills
C-159, Industrial Area
Site No. 1, B.S. Road, Ghaziabad, U.P.

20. M/s Cosmo Products
Ashoka Complex, Pachpedhi Naka
Dhamtari Road, Raipur - 492 001.

21. Grain Processing Industries (Indai) Pvt. Ltd.
29, Strand Road
Calcutta - 700 001. W. Bengal

22. Girnar Chemicals & Gas Industries Pvt. Ltd.
8, PUSHPAK
New Girdhar Park SOC.
Ambawadi, Ahemdabad - 380 006.

23. Netpro Renewable Energy (India) Ltd.
III Floor, GuptaTowers
50 / 1 Residency Road, Ist Cross
Bangalore - 560 025. Karnataka

Appendix - VII

Characteristics of paddy husk

S. No.	Characteristics	Value
1.	Bulk density (kg/m^3)	110.0
2.	Calorific value (MJ/kg)	14.1 - 15.5
3.	Fixed Carbon (%)	12.5
4.	Volatile (%)	71.0
5.	Ash (%)	16.5
6.	Carbon (%)	37.8
7	Hydrogen (%)	5.0
8.	Oxygen (%)	48.4
9.	Nitrogen (%)	0.3
10.	Silica (%)	15.6

Source: Bhatnagar, 1997.

Appendix - VIII

Performance of throat less gasifire engine at full load

S. No.	Characteristics	Value
1.	Composition of Producer gas (Volume %)	
2.	Carbon monoxide	19.8
3.	Hydrogen	12.2
4.	Carbon dioxide	12.4
5.	Methane	3.0
6.	Nitrogen	53.5
7.	Lower heating value of gas (MJ/Nm³)	4.4
8.	Engine speed (rpm)	1500.0
9.	Diesel replacement (%)	75.0
10.	Hot gas temperature (°C)	250 -280
11.	Engine Exhaust Temperature (°C)	350 - 380

Source: Bhatnagar. 1997.

Appendix - IX

Furnace boiler performance evaluation

S. No.	Characteristics	Value
1.	Husk feed rate (kg/hour)	780.0
2.	Steam production (kg/hour)	450.0
3	Pressure (kg cm⁻²)	12.0
4.	Combustion efficiency (%)	79.0
5.	Furnace efficiency (%)	49.0
6.	Overall Efficiency (%)	32.0
	Exhaust gas analysis (Volume %)	
7.	Carbon monoxide	1.8
8.	Carbon dioxide	12.5
9.	Hydrogen	1.22
10.	Nitrogen	76.5
11.	Oxygen	7

Source: Bhatnagar. 1997

Appendix - X

Biomass production and power generation in Memari block (Distt Burdhman)

Biomass	Quantity (tonne)	Power Generation Technology	Total kWh generation	If 20 kWh generator runs for 5 hrs/day	If 50 kWh generator runs for 5 hrs/day	If 50 kWh generator runs for 10 hrs day	If 1 MW generator runs for 5 hrs/day	If 1 MW generator for 8 hrs/day	If 1 MW generator runs for 16 hrs/day	Application possible	Pre- requisites
Cow dung	53557	?									* Evolve mechanism & understanding among villagers for sharing resources and benefits * Understanding among Forest Deptt. Electricity Board, villagers, private producer, etc. for processing & movement of wood, power generation, utilization and costs. * Suitable, proven technology with efficient technical backup * Mechanical efficiency of the systems to be considered * No individual mill has 500 MW demand. 1-2 group of industries exist
Wood											
Village forests	Negligible										
Govt forest	Negligible										
Social forestry	Negligible										
Saw dust	180	> 5 kW	120000	1200 Days (1080 Days) 3 unitsfor 362 days	480 days (432 Days) 2 units for 216 days	240 days (216days) 1 unit	24 days (21 days) 1 unit			* Power sustainability in saw-mills	
				200 kW for 5 hrs/day	500 kW for 5hr/day		1MW for 5 hr/day	1MW for 8 hrs/day	1 MW for 16hrs/day		
Rice husk	14159.59	>500 kW	9439726.7	9440 days (7552days) 25 units for 302 days	3776days (3021day) 10 units for 302 days	18879day (16992day) 50 units for 340 days	1888 days (1510day) 5 units for 302 days	1180 days (944days) 3 units for 315 days	590 days (472days) 2 units for 236 days	* Power sustainability in rice mills * Sale to Grid	* Transportation and processing costs (Detailed economic feasibility) * Practical aspects of pooling rice husk (costs, sharing of benefits, competition in business) Supply situation may change

Note: 1. 1 kWh power generation needs 1.5 kg biomass

* *Roughly 10% loss in biomass during transportation and processing (wood) and 20% loss in rice husk.*